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Assessment of Watershed Carrying Capacity and Land Use Change in Flood Vulnerability Areas in Semarang City

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Abstract

Human behavior can cause watershed problems, in which the use and carrying capacity of the watershed do not correspond. The objectives of this research are to determine the land use conditions and carrying capacity of the watersheds, and to analyze this capacity based on changes in land use and flood vulnerability areas. The research was conducted in five watersheds in flood-prone areas of Semarang City, namely Babon, Banjir Kanal Timur, Garang, Silandak, and Beringin, with a research area of 48,994.62 Ha. A quantitative analysis approach was used to calculate the land-use change and watershed carrying capacity; the capacity variables included land conditions, water quality, population, water building (ie. river embankments, river dams, and floodgates), and watershed space utilization. The results show that 1) an average of 12.27% of land in each watershed unit has been converted into settlements, with the most extensive conversion being in the Banjir Kanal Timur watershed; 2) the carrying capacity of this watershed got scored 113, which fell into the poor category; and 3) at the watershed level, the surge in land conversion into settlements correlates with the carrying capacity of the watershed. Conversion of land into settlements is one of the determinants of the carrying capacity of the watershed. If the land use arrangement in the watershed is made with consideration of flood-vulnerability areas, this will be able to reduce watershed damage and reduce the frequency of floods.

Keywords: watershed carrying capacity, land use change, flood, Semarang City

1. Introduction

A watershed is a land area enclosed by topographic water divisions, which in the event of rain channel the water into an interconnected river system to main river channel and eventually accumulate it through a single outlet (Setyowati, 2016). Potential problems include highly contrasting characteristics, such as excessive water flows in the rainy season (flood disasters), but drought in the dry season. These issues continue to develop over time, as land productivity declines in the upper section of watersheds.

The ability of a watershed to create the sustainability and harmony of its ecosystem and to optimize the benefits of natural resources for humans and other living creatures in a sustainable manner is called its 'carrying capacity' (Government Regulation No. 37 of 2012; Maulana et al., 2020). Natural and anthropogenic factors have rapidly changed the watershed landscape in recent decades (Afrin et al., 2019). Land cover and land use change can alter landscape patterns and affect regional ecosystems (Zhang et al., 2017). Vegetation also plays an important role in changing global or regional ecological environments (Nie et al., 2021). Moreover, the conversion of forests to agricultural land can cause the loss of hydrological functions associated with infiltration (Suprayogo et al., 2020). Research in the Rathbun watershed, South Central Iowa, USA shows that intensive agricultural use in the border area results in excessive erosion (ranging from 8.6 to 38.3 cm/year), leading to river flow damage and a decrease in the carrying capacity of the watershed (Tufekcioglu, 2020).

Changes in land use will affect the carrying capacity of watersheds. Population activities within them are a trigger or driving factor for their decline, such as increasing population pressure on land, water consumption patterns, and the level of urbanization, which are all important factors that affect their carrying capacity. The results of research by Deng et al. (2021), who applied the Driver-Pressure-Engineering water deficiency-State-Ecological basis-Response-Management (DPESBRM) concept to identify and assess the carrying capacity of karst area water resources, demonstrate that watershed carrying capacity (WCC) has increased year on year (Peng et al., 2021).

Land use refers to the way, and the purposes for which, humans employ the land and its resources, while land cover relates to the physical characteristics of the land, including human-made structures, which make up the earth's landscape. Historically, changes in land use and cover have occurred primarily in response to population growth, technological advances, and economic opportunities (Turner et al., 1995). Human activities have directly or indirectly modified the natural environment. This is due to the fact that production demands cannot be fulfilled without modification or conversion of land cover. Amongst the challenges facing the planet over the next century, land use and cover changes are likely to be the most significant (Nugraha & Utomowati, 2013; Mustard et al., 2012).

Beringin, Silandak, Garang, Banjir Kanal Timur, and Babon are national priority rivers in Indonesia that need to be managed (BPDAS, 2015). Five main watersheds in Semarang City have experienced land use changes which have caused floods in the downstream area of the river. Some areas are at risk of flooding due to violation of spatial planning, and consequently narrowing of the water retention area upstream. Land-use conversion requires serious attention, as it potentially interferes with watershed responses to rainfall, from less water infiltration into soil layers, to reduced groundwater aquifer capacity and an increased ratio of direct runoff to rainfall, the combination of which leads to floods (Setyowati, 2019; Eman et al., 2016). The damage to the watershed is in the form of sedimentation in rivers and at river mouths, the occurrence of high discharge fluctuations, and a fall in river quality. Rivers consequently become shallower and cannot accommodate rainwater, causing the water to overflow, which leads to flooding.

Floods result from rivers that overflow and pass over riverbanks, with water affecting settlements because rivers are unable to accommodate the rainfall (Asdak, 2010). Data on the number of flood events in the five watersheds in Semarang City from 2011 to 2015 show that

Babon watershed suffered ten flood events; Banjir Kanal Timur 24 events; Garang 16; Silandak 16; and Beringin watershed 14 events (BPDAS, 2015). Flood events hit the coastal areas of Semarang City, covering the areas of Genuk District, Gayamsari District, East Semarang District, Tugu District, West Semarang District, and North Semarang District. The flood phenomena result from the increased water discharge into the Beringin River, Silandak River, Garang River, Banjir Kanal Timur, and Babon River.

One of the causes of flood vulnerability in Semarang City is changes in land use in the watershed. Changes in watershed carrying capacity due to these land use changes also affect flood vulnerability in the city. The level of vulnerability is categorized as bad or moderate, with the Banjir Kanal Timur watershed having a bad WCC value, and Beringin watershed, Garang watershed, Silandak watershed, and Babon watershed moderate values.

The purpose of the study is to determine the condition of land use in 2002 and 2018 in the five watersheds as estuary the city of Semarang, and to analyze the carrying capacity of the watersheds based on changes in land use and flood vulnerability.

2. Research Method

The study mainly used a quantitative approach, with supporting qualitative descriptive methods. The research location was Semarang City, Indonesia. The research objects were watersheds that flow into Semarang city, namely Silandak, Beringin, Garang, Babon, and Banjir Kanal Timur (Figure 1).

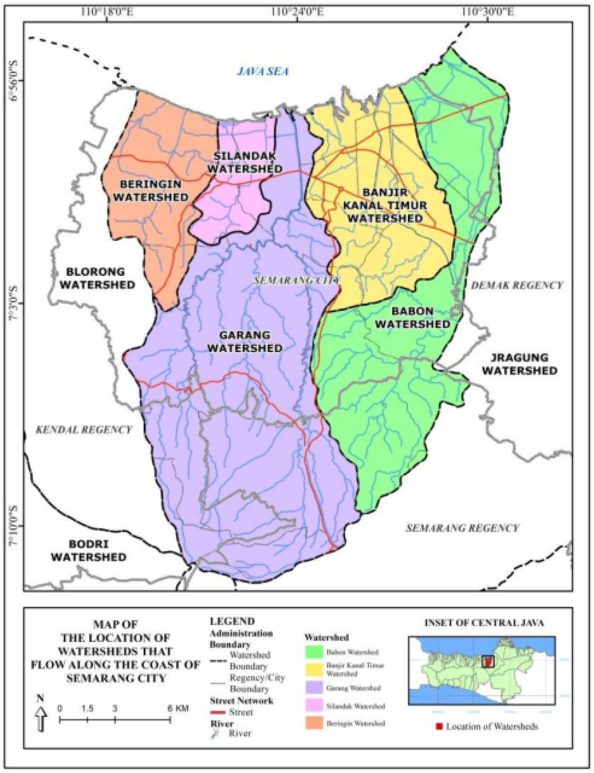

Figure 1. Locations of the Five Watersheds that Flow Along the Coast of Semarang City

The primary data included observation and checking of image interpretation, including land use information and flood vulnerability data in the five watershed locations. Secondary data were obtained from geomorphological maps, soil maps, BPS data, and archive data from reports on the hydrological conditions of watersheds in Semarang City obtained from the Pemali Jratun Watershed Management Center (BPDAS). These data included information on land conditions in the form of critical land area and vegetation cover; watershed hydrological data; social, economic, and institutional data; water construction investment data; and data on the use of protected and cultivated areas.

Land use data were obtained from the interpretation of Landsat 7 ETM+ and Landsat 8 OLI (Operational Land Imager) satellite images to determine the area and type of land use. Landsat 7 ETM satellite imagery for was used to make land use maps in 2002 and Landsat 8 imagery from 2016 together with field checking was used to establish land use in 2018. Landsat 8 OLI is a generation 8 landsat satellite that describes the land surface with a multispectral spatial resolution of 30 m and panchromatic of 15 m. Land use change was calculated from 2002 and 2018 data.

Data analysis techniques consisted of spatial analysis of land use changes and WCC analysis. The spatial analysis was applied to determine the area, location, and land use changes in the five watersheds in Semarang City. The types of land use were forest, mixed garden, settlement, rice field, dry cultivated land, open land, and water body (Table 1).

Table 1. Description of Land Use Types

No	Land Use	Description of Land Cover (according to SNI, scale 1: 250,000)
1.	Forest	Land for conservation areas, which extended on dry land habitats in the form of lowland forests, mountains or hills. Some types of forest have not experienced human intervention, while others have (there are traces of logging).
2.	Mixed Garden	Land associated with rural garden areas, planted with annual plants of more than one type or not uniformly. The method of harvesting the produce does not involve the cutting down of trees.
3.	Settlement	Land used as a residential environment and a place for activities that support human life.
4.	Rice Field	Cultivated land for agricultural activities of short-lived food crops, in this case rice, using irrigation or rain-fed systems.
5.	Dry Land	Cultivated land for agricultural activities of seasonal crops on dry land, using a rain-fed system.
6.	Open Land	Unproductive land because it is not used by humans; usually without land cover or shrubs.
7.	Water Body	Cultivated in the form of ponds or swamps in coastal areas, in the form of large brackish water puddles, involving fishing or salt production activities.

The analysis of the carrying capacity of the watersheds used the criteria stipulated in the Regulation of the Minister of Forestry of the Republic of Indonesia Number: P.61/Menhut-II/2014, with modifications in the form of sub-indicator reduction if no data were available. The WCC indicators used were the same as the five indicators from the regulation of the minister, while the sub-indicators that were reduced were the annual flow coefficient, sediment load, water use index, and the level of population welfare. The analysis of the WCC involved five assessment indicators, namely land conditions; water quality, quantity and continuity; social, economic and institutional; water construction investment; and use of regional space. The assessment scores for the WCC evaluation were obtained from the results of the analysis with the value of the weights and scores of the indicators and their parameters. The WCC assessment is presented in Table 2.

Table 2. WCC Assessment

No	WCC Indicator	Weight %	Value Lowest	Value Highest
1.	Land Condition	40	20	60
	a. Percentage of Critical Land	20	10	30
	b. Percentage of Vegetation Cover	10	5	15
	c. CP value	10	5	15
2.	Water Quantity and Continuity (Water Management)	20	10	30
	a. Annual Flow Coefficient	12	6	18
	b. Flood	8	4	12
3.	Socio-Economic and Institutional	20	10	30
	a. Population Pressure on Land	14	7	21
	b. Presence and Enforcement of Regulations	6	3	9

4.	Water Building Investment	10	5	15
	a. City Classification	5	2.5	7.5
	b. Water Building Value Classification	5	2.5	7.5
5.	Territorial Space Utilization	10	5	15
	a. Protected Area	5	2.5	7.5
	b. Cultivation Area	5	2.5	7.5
	Total		50	150

Source: Adapted from the Regulation of the Minister of Forestry of the Republic of Indonesia Number: P.61/Menhut-II/2014 with WRCC (Deng et al., 2021)

Based on the results of the WCC assessment, these were grouped, as presented in Table 3.

Table 3. WCC Classification

No	Value	Category
1.	WCC ≤ 70	Very Good
2.	70 < WCC ≤ 90	Good
3.	90 < WCC ≤ 110	Moderate
4.	110 < WCC ≤ 130	Bad
5.	WCC > 130	Very bad

Source: Regulation of the Minister of Forestry of the Republic of Indonesia Number: P.61/Menhut-II/2014 concerning Monitoring and Evaluation of Watershed Management.

3. Results and Discussion

3.1. Land Use of the Five Watersheds in 2002 and 2018

Land use often involves types of business activity or includes use such as agriculture, plantations, grasslands, and settlements which refer to the function of land cover (Lin et al., 2008). The form of land use that is interpreted from an image must be adjusted to the type of image and the results of the interpretation are tested for truth. Based on the results of the interpretation of the Landsat 7 ETM+ images recorded in 2002 and Landsat 8 OLI images recorded in 2016, together with the field checks in May 2018, land use data were generated at the five watershed. The accuracy of the land use maps resulting from the image interpretation was checked by field survey activities on each land use class sample using a GPS (ground check) tool to verify the results of the land use image interpretation and to establish current land use. Furthermore, the results of the calculation of the accuracy test produced a value of 93%, meaning the results met the minimum limit of 85% required by the United States Geological Survey, USGS.

Land use change is the result of human intervention, either permanently or cyclically, in a group of natural and artificial resources as a whole called land, with the aim of fulfilling needs of human life. Changes in land use involve changes in land cover, for example changing from forest to agricultural land, from agricultural land to residential areas or industrial land, or from grassland land to residential land.

In the Babon watershed, there has been an increase 70% in the area of settlements from 1,492.24 Ha in 2002 to 2,540.14 Ha in 2018. This is inversely proportional to the reduction

35.12% in paddy fields from 3,107.91 Ha in 2002 to 2,300.15 Ha in 2018. The data on land use conditions in the Babon watershed in 2002 and 2018 are presented in Table 4 and Figure 2.

Table 4. Types of Land Use in the Five Watersheds in Semarang City, 2002 and 2018

Watersheed	Total Area (Ha)	Area of land use in 2002 and 2018 (hectares)						
		Forest	Mixed Garden	Open Land	Settlement	Rice Field	Dry Land	Water Body
Babon	12,177.19	2,106.46	743.56	88.51	1,492.24	3,107.91	3,617.54	1,020.98
		1,726.52	1,049.28	54.89	2,540.14	2,300.15	3,630.23	875.98
Banjir Kanal	7,858.03	120.24	330.39	90.43	3,863.82	641.06	2,094.59	569.95
Timur		55.94	384.18	72.55	5,541.42	464.66	863.15	328.58
Garang	21,277.36	8,479.45	1,652.77	91.67	2,018.81	4,911.18	3,961.87	151.01
		8,461.02	1,725.69	51.25	3,608.90	2,710.82	4,548.91	160.18
Silandak	2,391.42	78.97	133.87	50.72	902.98	202.22	456.21	538.86
		10.87	186.29	44.14	1,243.66	327.35	226.37	325.15
Beringin	5,176.12	719.56	726.42	68.96	761.26	868.56	843.06	1,188.31
		504.82	1,037.53	56.14	1,231.63	769.92	518.24	1,057.42

Source: Analysis of Map and Data (Figure 2)

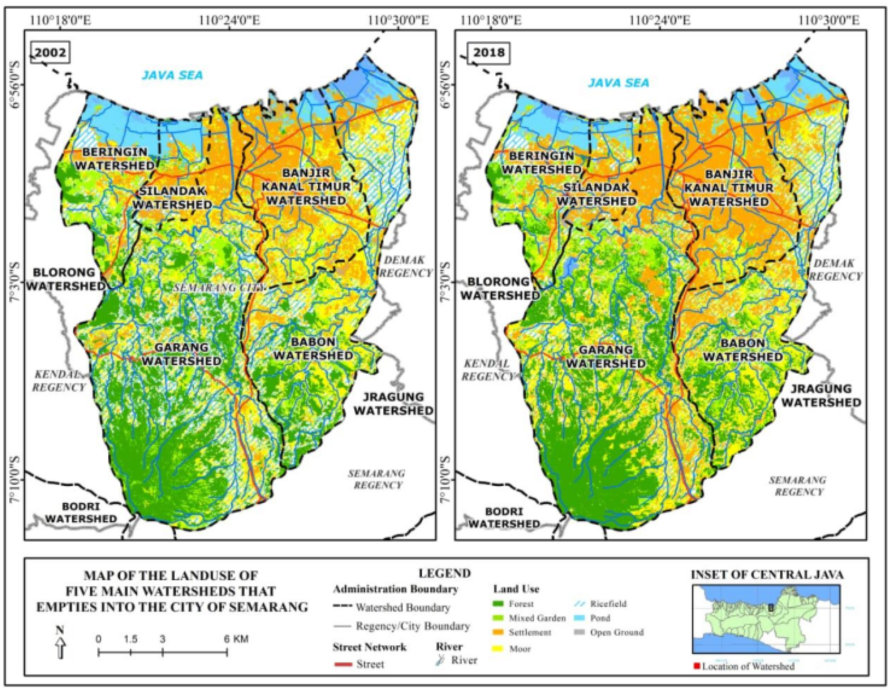

Figure 2. Land Use Map of Silandak Watershed, Beringin Watershed, Banjir Kanal Timur Watershed, Garang Watershed, and Babon Watershed, 2002 and 2018

The pattern of land use change in the five watersheds is relatively similar: the areas of settlements and mixed gardens have increased, whereas those of forest, open land, rice fields, dry land and water bodies have decreased. The percentage increase in the area of settlements varies; the Banjir Kanal Timur and Silandak watersheds have seen the largest percentage increases, while the corresponding increase in the other three watersheds is less than 10% (Figure 2).

With regards to the Banjir Kanal Timur watershed, in 2002 the settlement area was 3,863.82 Ha, which by 2018 had increased to 5,541.42 Ha, an increase of 43.42% (1,677.60 Ha). In the Garang watershed, the area of settlement increased by 78.76% (1,590.09 Ha), from 2,018.81 Ha in 2002 to 3,608.90 Ha in 2018. The area of settlements in the Silandak watershed dropped significantly from 1,243.66 Ha in 2002 to 902.98 Ha in 2018, or 37.72% (340.68 Ha). The Babon watershed settlement area increased by 8.61% (1,047.9 Ha), from 1,492.24 Ha in 2002 to 2,540.14 Ha in 2018. Settlements in the Beringin watershed in 2002 covered an area of 761.26 Ha, which by 2018 had risen to 1,231.63 Ha, an increase of 61.78% (470.37 Ha). Details of land use in 2002 and 2018 are presented in Table 4 and Figure 3.

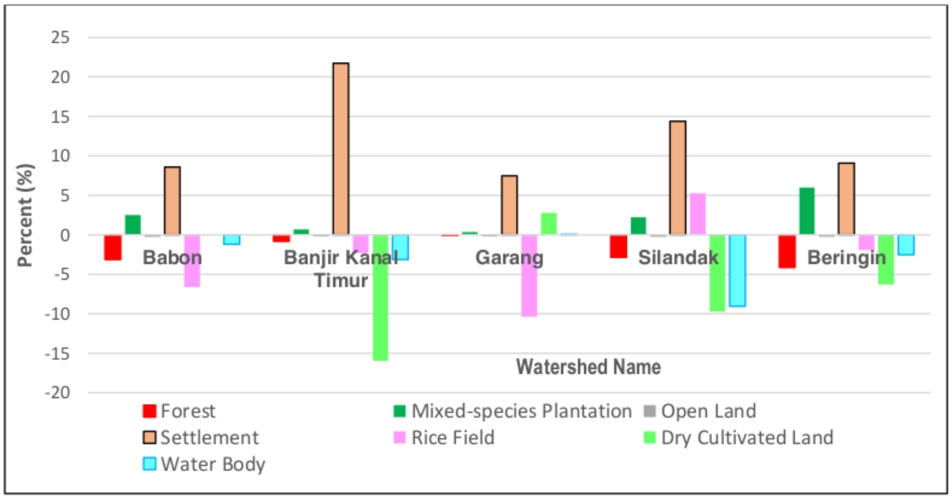

Figure 3. Land Use Change 2002-2018 in the Five Watersheds in Semarang City

The relationship of human behavior and environment must be in harmony by utilizing land and water resources in line with the environment's carrying capacity. Overexploitation that reduces the carrying capacity of a watershed can trigger environmental degradation, while an increase in settlements around the watershed will reduce the environmental quality.

3.2. WCC of the Five Watersheds in 2002 and 2018

The carrying capacity of the five watersheds followed the Regulation of the Minister of Forestry No. P.61/Menhut-II/2014. WCC Value obtained from from the weight values of the research indicators and their respective parameters. Mathematically, carrying capacity was the sum of the multiplication products of the scores obtained through the data analysis by the weight value of each parameter. The results of the assessment of the carrying capacity of the five watersheds are presented in Table 5.

Table 5. WCC Calculation of the Five Watersheds in Semarang City

Watershed Carrying Capacity (WCC) Indicator	Babon Watershed		BKT Watershed		Garang Watershed		Silandak Watershed		Beringin Watershed	
	Data	WCC	Score	WCC	Nilai	WCC	Nilai	WCC	Nilai	WCC
1. Land Condition										
a. Percentage of Critical Land	1.60	10	0.28	10	3.03	10	0	10	0	10
b. Percentage of Vegetation Cover	22.58	12.5	5.60	15	47.88	10	8.24	15	29.81	12.5
c. Factor Value	0.19	7.5	0.40	10	0.14	7.5	0.3	7.5	0.16	7.5
2. Water Quantity and Continuity										
a. Annual Flow Coefficient	0.2	6	0.68	18	0.19	6	1.77	18	0.58	18
b. Flood (times)	2	12	5	12	3	12	3	12	3	12
3. Socio-Economic and Institutional										
a. Population Pressure on Land	0.2	21	0.31	21	0.41	21	0.15	21	0.28	21
b. Enforcement of Regulations	0	4.5	0	4.5	0	4.5	0	4.5	0	4.5
4. Water Building Investment										
a. City Classification	376.033	5	728.372	6.25	523.060	6.25	104.768	5	101.853	5
b. Water Building Value (billion rupiah)	135.7	7.5	55.86	6.25	981.09	7.5	25.4	3.75	34.45	5
5. Territorial Space Utilization										
a. Protected area (%)	56.51	3.75	0	7.5	42.27	5	0	7.5	36.91	5
b. Cultivation Area (%)	87.67	2.5	92.52	2.5	65.35	3.75	90.60	2.5	78.87	2.5
WCC value =		**92.25**		**113**		**93.5**		**107**		**103**
Classification =		Moderate		Bad		Moderate		Moderate		Moderate

The Banjir Kanal Timur watershed, with an area of 7,858.03 Ha, has a WCC value of 113. This indicates that the current condition of the watershed has a poor classification of 110 < WCC 130. Attention needs to be paid to the watershed urgently in a comprehensive and integrated manner considering its poor WCC condition. Each indicator in this watershed shows a higher value, meaning that the final value of its carrying capacity is also poor.

On the other hand, the Babon watershed, with an area of 12,291.69 Ha, has a WCC value of 92.25 or 90 < WCC 110, which is in the moderate category, but shows that the watershed had not met the criteria for becoming one with good carrying capacity. Several WCC indicators need attention to improve WCC the condition. Meanwhile, the Garang watershed's carrying capacity assessment result was 93.5, also classified in the moderate category. Based on this assessment, the carrying capacity of this watershed needs to be maintained, particularly in terms of land conditions, water management, and regional spatial planning. In addition, the Garang watershed area is vast, so its management must be comprehensive.

The Silandak watershed is a small watershed with an area of 2,391.42 Ha and a WCC assessment score of 107, which is in moderate classification concerning its carrying capacity, although the score is close to the limit for poor watershed classification. If there is no corrective action on each indicator or parameter, this will result in the watershed's carrying capacity turning from moderate to poor. The carrying capacity of the Beringin watershed is also in the moderate classification, with a WCC value of 103 or 90 < WCC 110. This watershed, with an area of

5,176.12 Ha, is in the medium classification based on its carrying capacity assessment. However, the Beringin watershed has several problems, such as the condition of the land and water system and the use of regional space, which affect the final WCC score.

Based on the calculation results, the carrying capacity of the five watersheds observed in this study was moderate or bad. Babon, Garang, and Beringin had moderate carrying capacity, while Banjir Kanal Timur fell into the bad category. Although the carrying capacity of Silandak was classified as moderate, it was bordering on bad. Babon, Garang, Silandak, and Beringin need to maintain the current conditions of the relevant indicators, including land, water systems, socioeconomic circumstances, building investment, and spatial use in the region.

The carrying capacity was initially proposed in the ecological community and was adopted to measure the maximum of individuals maintaining a certain species in a certain area under certain conditions. Nowadays, the carrying capacity has been extended into hydrological sciences and is widely used to represent the capacity of the environment or ecosystem to sustain development and specific activities (Deng et al., 2021; Yuan & Tian, 2008). Carrying capacity originated in the fields of demographics and ecology and was discussed within the scope of resource consumption and environment degradation resulting from excessive human activities (Bao et al., 2020).

3.3. Watershed Carrying Capacity Reviewed from Land Use and Flood Vulnerability

The land use of each watershed determines the carrying capacity indicators or parameters analyzed in this study, mainly through the effect of conversion into built-up land or settlements. In general, residential land use continues to grow year by year. The Banjir Kanal Timur watershed experienced the highest increase in settlement area (43.41%), from 3,863.82 Ha in 2002 to 5,541.42 Ha in 2018, meaning that the WCC score was high at 113 and the carrying capacity was therefore bad.

The relationship between WCC and changes in built-up land, particularly settlements, were presented in Table 6 and Figure 4. The higher the percentage change in residential land use, the greater the carrying capacity of the watershed. The Banjir Kanal Timur watershed, which has a high percentage of settlement changes, also experienced a decrease in watershed carrying capacity. The dominant land use changes that occur are conversion from forest into agricultural land, and conversion of some agricultural land (rice fields, mixed gardens, dry fields, water bodies) into settlements. The area of settlements in the form of built-up land is increasing annually.

The development of settlements in the lower part of Semarang City, precisely in the downstream area of the river from the Banjir Kanal Timur River and the Garang River, has resulted in an alluvial plain landscape. Geomorphologically, alluvial plains from rivers or beaches are areas vulnerable to flooding (Dahlia et al., 2016). The area of the alluvial plain in the Banjir

Kanal Timur watershed is 38.59%; that in the Babon watershed is 45.15%; while the area in the Garang watershed is 6.73%, in Silandak 4.02%, and in Beringin (5.52%) (Table 6). The estuary is the most vulnerable area, because it is a large water catchment area, a wide estuary valley, and a meeting point of the flow outlets from rivers that enter the sea, but there are also fluctuations in ocean waves. Coastal landscapes are areas that are prone to flooding, which might result in erosion (Rogers & Woodroffe, 2016).

Table 6. Assessment of Watershed Carrying Capacity by Land Use Area

Name of Watershed	Watershed Area (Ha)	Settlement Area (%)	Change in Settlement Area 2002-2018 (%)	Watershed Carrying Capacity (%)	Area of Alluvial Plains (%)
Babon	12,291.69	20.86	8.61	61.5	45.15
Banjir Kanal Timur	7,858.03	71.87	21.35	75.3	38.59
Garang	21,277.36	16.97	7.48	62.3	6.73
Silandak	2,391.42	52.61	14.25	71.3	4.02
Beringin	5,176.12	23.80	9.09	68.7	5.52
Amount =	48,994.62				

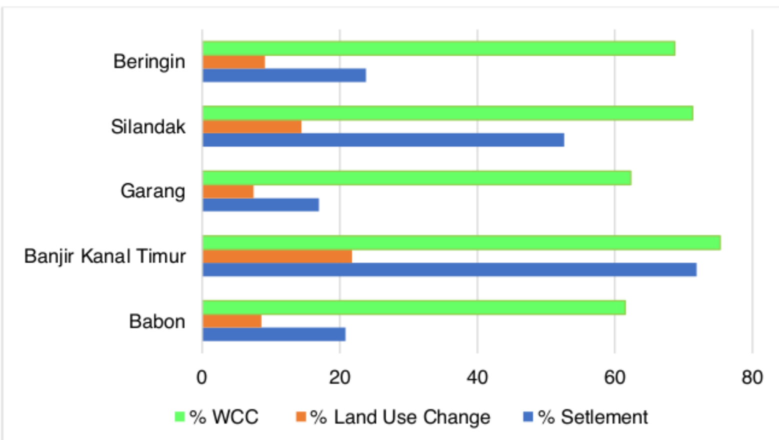

Figure 4. Percentage of Watershed Carrying Capacity by Settlement Area

Changes in land use to settlements directly affect the decline in land cover vegetation and land or plant management functions (Nugraha & Utomowati, 2013; Mustart, 2012). The changes also impact the watershed's capacity in water management conditions because the annual water flow increases when the forest and vegetation area is significantly reduced or the vegetation type changes from deep-rooted to shallow-rooted plants. The more significant the change in land use, such as from forest to agricultural land, or from rice and dry fields into settlements, the greater the changes in surface water flow. Moreover, changes in land use into industrial areas, offices and settlements are mostly located in the alluvial plains of the rivers and beaches of Semarang City. The lower part of Semarang City, which is located on the alluvial plain, is prone to flooding. Changes in land use and physical environmental conditions, especially mofometry and landforms, need to be the focus of attention, because there is a correlation between land use and physical conditions in the watershed, which can increase runoff and flooding (Bisht et al., 2018; Rogers & Woodroffe, 2016). The upstream watershed ecosystem is essential because it has protective functions for all parts of the watershed, one being as a water system function that can reduce the impact of floods (Susanti et al., 2020). Both land use and land cover can greatly impact the hydro-ecological processes of the watershed, including ecosystem productivity, evapotranspiration, soil infiltration, and runoff. Some studies have shown that agricultural practices, urbanization, deforestation, and industrialization are major drivers which affect water quality and quantity (Alemayehu et al., 2009).

4. Conclusion

The watersheds in Semarang City experienced significant changes in land use, especially an increase in settlement area (with an average of 12.27%), between 2002 and 2018. The level of settlement expansion in the Banjir Kanal Timur watershed is 21.76%, resulting in a high WCC value of 113, meaning that the carrying capacity of the watershed is categorized as bad. WCC conditions in the Silandak, Baboon, Garang and Beringin watersheds are in the moderate category, so they must continue to be managed. WCC parameters include land conditions, water quality, population conditions, water building (ie. river embankments, river dams, and floodgates), and watershed space utilization. Conversion of land into settlements is one of the determinants of the carrying capacity of watersheds. Spatial planning in the upstream and downstream watersheds will be able to reduce watershed damage and reduce the frequency of flooding in coastal rivers, while considering the flood vulnerability of Semarang City. Policy formulation is based on land conditions, vegetation cover, water management, and sustainable use of space according to the carrying capacity of the watershed. Collaboration between all parties, institutions and individuals, involved in watershed management, including government agencies, the private sector, and the community, must be strongly developed in order to realize watersheds with sustainable carrying capacity.

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